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Evaluation Board for the ADF4150 PLL Frequency Synthesizer

FEATURES

General-purpose evaluation board for ADF4150, including VCO, loop filter, and TCXO
Contains the ADF4150 frequency synthesizer (500 MHz to 5 GHz)
Accompanying software allows complete control of synthesizer functions from a PC

EVALUATION KIT CONTENTS

EVAL-ADF4150EB1Z board
CD that includes
Self-installing software that allows users to control the board and exercise all functions of the device
Electronic version of the ADF4150 data sheet
Electronic version of the UG-380 user guide

ADDITIONAL EQUIPMENT

PC running Windows XP or more recent version
Power supply
Spectrum analyzer
Oscilloscope (optional)

DOCUMENTS NEEDED

ADF4150 data sheet

REQUIRED SOFTWARE

Analog Devices ADF4150 software (Version 3 or higher)
ADIsimPLL

GENERAL DESCRIPTION

This board is designed to allow the user to evaluate the performance of the ADF4150 frequency synthesizer for phase-locked loops (PLLs). Figure 1 shows the board, which contains the ADF4150 synthesizer, loop filter, voltage control oscillator (VCO), reference oscillator (TCXO) of 25 MHz frequency for the reference input, power supply connectors, and an RF output.

The evaluation kit also contains software that is compatible with Windows® XP and later versions to allow easy programming of the synthesizer.

A USB port in the PC is required to program the part.

EVALUATION BOARD

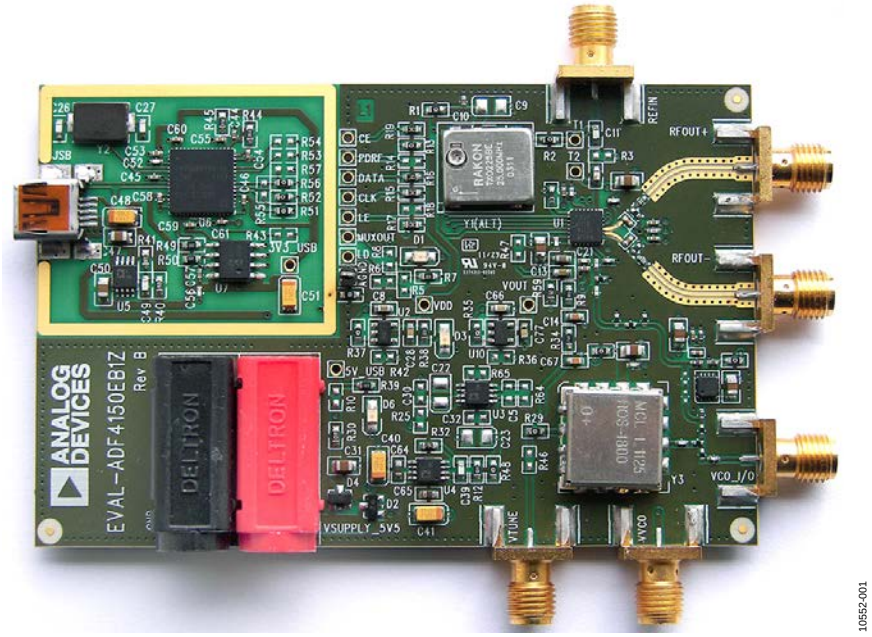

Figure 1. EVAL-ADF4150EB1Z

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REVISION HISTORY

3/12—Revision 0: Initial Version

QUICK START GUIDE

Follow these steps to quickly evaluate the ADF4150 device:

1. Install the ADF4150 software.
2. Connect the ADF4150EB1Z evaluation board to the PC
3. Follow the hardware driver installation procedure.
4. Connect the power supplies to banana connectors (5.5 V).
5. Run the ADF4150 software.
6. Connect the spectrum analyzer to SMA connector VCO_I/O.
7. Measure the results.

EVALUATION BOARD HARDWARE

The EVAL-ADF4150EB1Z schematics are shown in Figure 23, Figure 24, Figure 25 and Figure 26. The silkscreen of the evaluation board is shown in Figure 2.

POWER SUPPLIES

The board is powered from external banana connectors. The supply voltage should be 5.5 V. The power supply circuit uses high precision, low noise ADP150AUJZ-3.3 linear regulators and ADP3334ARMZ adjustable LDO regulators to provide 3.3 V to V_{DD} on the board (which supplies the ADF4151 AV_{DD} , DV_{DD} , and SDV_{DD} pins) and 5 V to the ADF4150 V_P.

INPUT SIGNALS

The reference signal is necessary for proper operation of the synthesizer. It can be sourced from a provided TCXO or an external generator, which can be connected to the REFIN edge mount connector. To use an external reference generator, it is necessary to remove R1 and R2 to disconnect the TCXO from the reference input and from the supply. R3 can be populated with a 50 Ω resistor to adjust the impedance matching of the evaluation board to the external reference source.

Digital SPI signals are supplied from the Cypress microcontroller, U6, which is used for communication with the USB port of the PC.

OUTPUT SIGNALS

All components necessary for LO generation are inserted on the board. The PLL is made up of the ADF4150 synthesizer, a fourth-order passive loop filter, and the VCO. The loop filter must be inserted between the charge pump output and the VCO input, as shown in Figure 26. If replacing the VCO, a VCO in a T-package (or similar) must be used. The RF output is available at the edge mount SMA connector, VCO_I/ O, and the differential RF output of the part is connected to the RFOUT+ and RFOUT– edge mount SMA connectors.

DEFAULT OPERATION SETTINGS

This board is shipped with a TCXO that provides a reference frequency of 25 MHz, a fourth-order low-pass filter with 30 kHz bandwidth at I_{CP} = 2.325 mA, and a VCO with a 1.7 GHz to 1.8 GHz frequency range. To test the performance of the part for a different frequency range and different loop filter, the relevant components on the board must be changed.

ADDITIONAL OPTIONS

The VVCO connector can be used as a test point to measure the supply voltage of the VCO in its default configuration. It can also be used to provide an external supply for the on-board VCO; however, if an external supply for VCO is used, Resistor R31 must be removed to disconnect the connector from the output of the on-board voltage regulator.

Optionally, an external VCO can be used. In this case, it is necessary to remove R29 and insert a 0 Ω link at R46 to form a connection between the loop filter output and the VTUNE SMA edge mount connector. Remove R31 to disconnect the on-board VCO from the power supply. Remove Resistor R26 to disconnect the output of the on-board VCO from the RF signal path, and replace Resistors R27 and R28 with 0 Ω links to ensure operation of the VCO_I/O connector as an input from an external VCO.

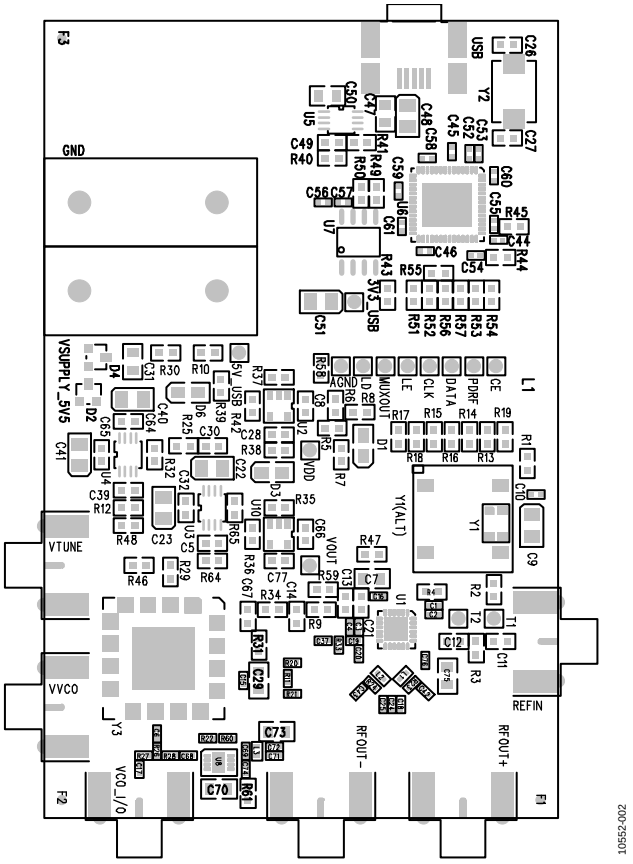


Figure 2. Evaluation Board Silkscreen

EVALUATION BOARD SETUP PROCEDURE

SOFTWARE INSTALLATION

Use the following steps to install the software.

1. Install the Analog Devices ADF4150 software by double-clicking **ADF4150 Setup.msi**.
   If you are using Windows XP, follow the instructions in the Windows XP Software Installation Guide section (see Figure 3 to Figure 7).
   If you are using Windows Vista or Windows 7, follow the instructions in the Windows Vista and Windows 7 Software Installation Guide section (see Figure 8 to Figure 12).
   Note that the software requires Microsoft Windows Installer and Microsoft .NET Framework 3.5 (or higher). The installer connects to the Internet and downloads Microsoft .NET Framework automatically. Alternatively, before running the **ADF4150 Setup.msi**, both the installer and .NET Framework can be installed from the CD provided.
2. Connect your board by USB.
   If you are using Windows XP, follow the steps in the Windows XP Driver Installation Guide section (see Figure 13 to Figure 16).
   On Windows Vista or Windows 7, the drivers install automatically.

Windows XP Software Installation Guide

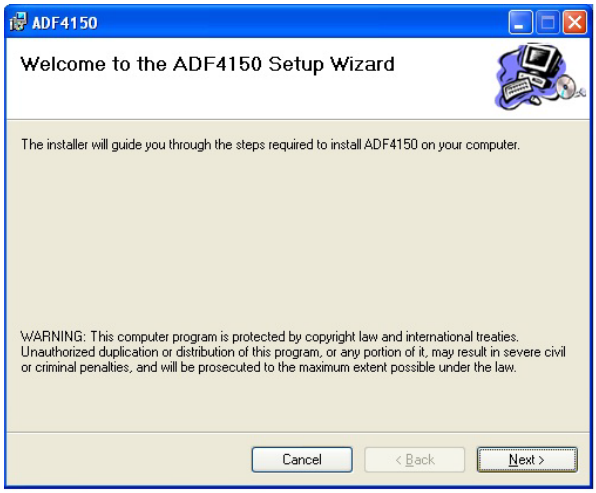

ADF4150
Welcome to the ADF4150 Setup Wizard
The installer will guide you through the steps required to install ADF4150 on your computer.
WARNING: This computer program is protected by copyright law and international treaties. Unauthorized duplication or distribution of this program, or any portion of it, may result in severe civil or criminal penalties, and will be prosecuted to the maximum extent possible under the law.
Cancel
< Back
Next >
10552-003

Figure 3. Windows XP ADF4150 Software Installation, Setup Wizard

1. Click **Next**.

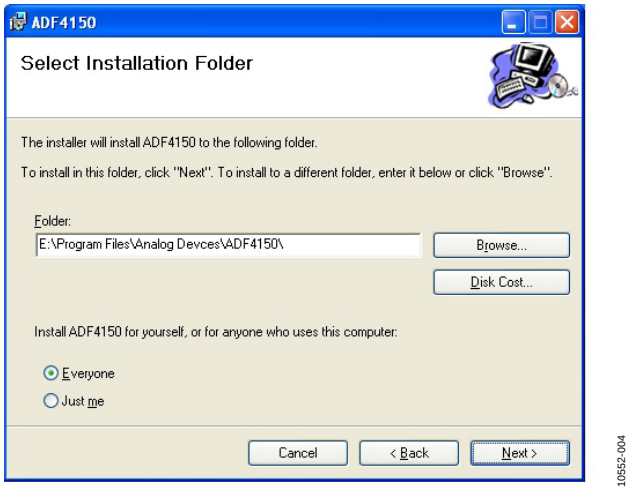

ADF4150
Select Installation Folder
The installer will install ADF4150 to the following folder.
To install in this folder, click "Next". To install to a different folder, enter it below or click "Browse".
Folder:
E:\Program Files\Analog Devices\ADF4150\
Browse...
Disk Cost...
Install ADF4150 for yourself, or for anyone who uses this computer:
Everyone
Just me
Cancel
< Back
Next >
10552-004

Figure 4. Windows XP ADF4150 Software Installation, Select Installation Folder

2. Choose an installation directory and click **Next.**

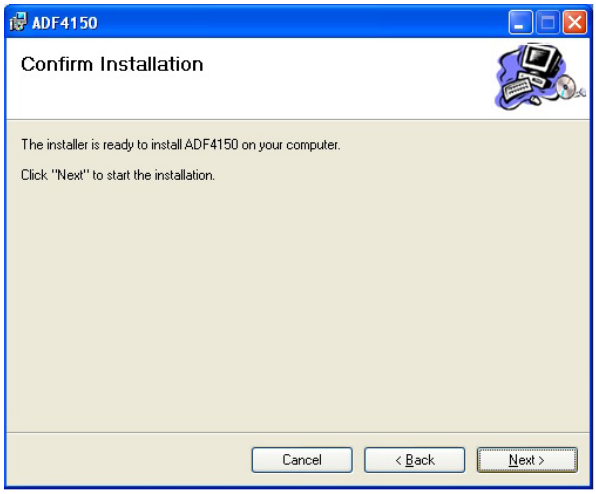


Figure 5. Windows XP ADF4150 Software Installation, Confirm Installation

3. Click **Next.**

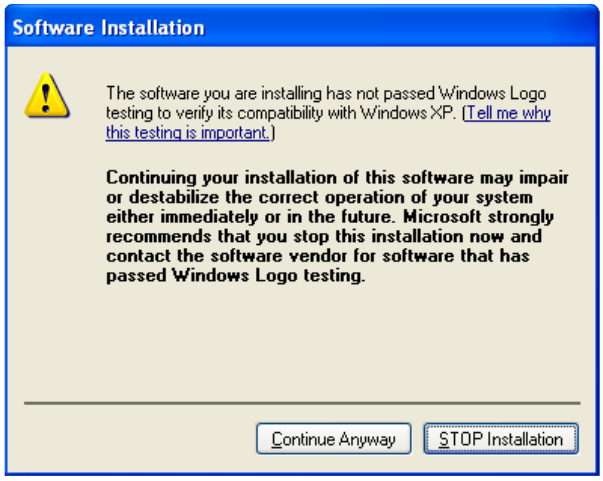

Software Installation
The software you are installing has not passed Windows Logo testing to verify its compatibility with Windows XP. (Tell me why this testing is important.)
Continuing your installation of this software may impair or destabilize the correct operation of your system either immediately or in the future. Microsoft strongly recommends that you stop this installation now and contact the software vendor for software that has passed Windows Logo testing.
Continue Anyway
STOP Installation
10552-006

Figure 6. Windows XP ADF4150 Software Installation, Logo Testing

4. Click **Continue Anyway**.

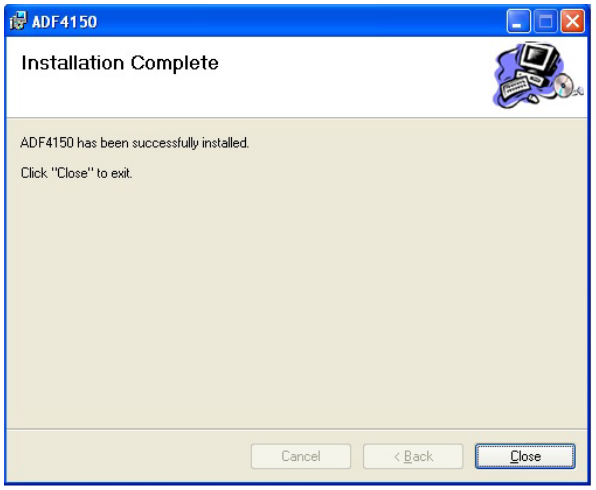
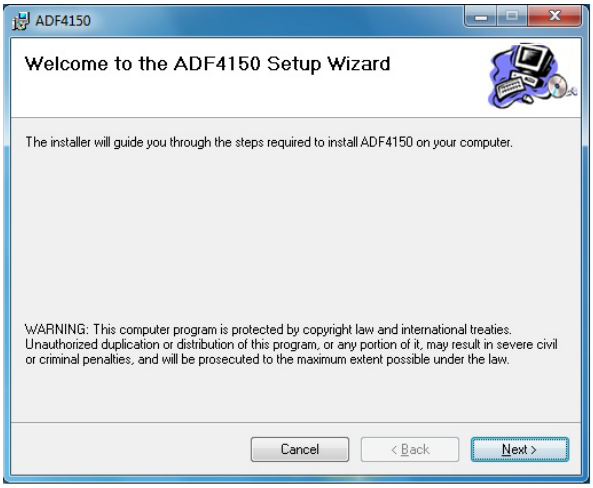


Figure 7. Windows XP ADF4150 Software Installation, Installation Complete

5. Click **Close.**

Windows Vista and Windows 7 Software Installation Guide


ADF4150
Welcome to the ADF4150 Setup Wizard
The installer will guide you through the steps required to install ADF4150 on your computer.
WARNING: This computer program is protected by copyright law and international treaties. Unauthorized duplication or distribution of this program, or any portion of it, may result in severe civil or criminal penalties, and will be prosecuted to the maximum extent possible under the law.
Cancel
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Next >
10552-008

Figure 8. Windows Vista/7 ADF4150 Software Installation, Setup Wizard

1. Click **Next**.

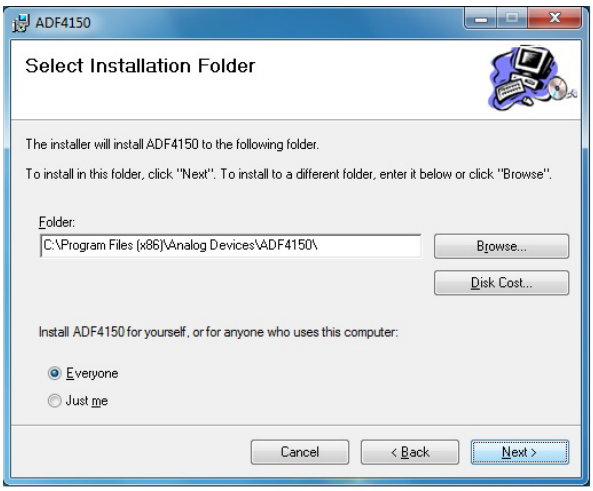
ADF4150
Select Installation Folder
The installer will install ADF4150 to the following folder.
To install in this folder, click "Next". To install to a different folder, enter it below or click "Browse".
Folder:
C:\Program Files (x86)\Analog Devices\ADF4150\
Browse...
Disk Cost...
Install ADF4150 for yourself, or for anyone who uses this computer:
Everyone
Just me
Cancel
< Back
Next >
10552-009

Figure 9. Windows Vista/7 ADF4150 Software Installation, Select Installation Folder

2. Choose an installation directory and click **Next.**

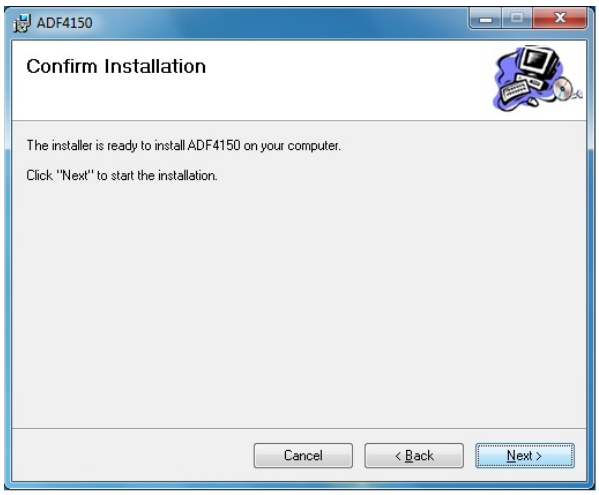

Figure 10. Windows Vista/7 ADF4150 Software Installation, Confirm Installation

3. Click **Next**.

Windows Security
Would you like to install this device software?
Name: Analog Devices, Inc Universal Serial Bus...
Publisher: Analog Devices B.V.
Always trust software from "Analog Devices B.V.".
Install
Don't Install
You should only install driver software from publishers you trust. How can I decide which device software is safe to install?
10552-011

Figure 11. Windows Vista/7 ADF4150 Software Installation, Start Installation

4. Click **Install**.

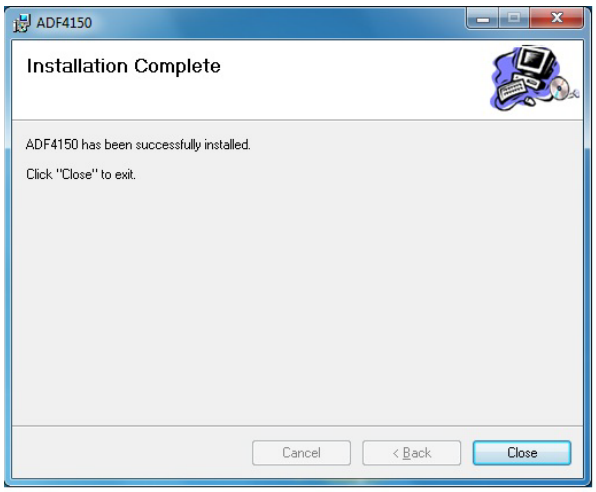

Figure 12. Windows Vista/7 ADF4150 Software Installation, Installation Complete

5. Click **Close**.

Windows XP Driver Installation Guide

Found New Hardware Wizard
Welcome to the Found New Hardware Wizard
Windows will search for current and updated software by looking on your computer, on the hardware installation CD, or on the Windows Update Web site (with your permission).
Read our privacy policy
Can Windows connect to Windows Update to search for software?
Yes, this time only
Yes, now and every time I connect a device
No, not this time
Click Next to continue.
< Back
Next >
Cancel
10552-013

Figure 13. Windows XP USB Driver Installation, Found New Hardware Wizard

1. Choose **Yes, this time only** and click **Next**.

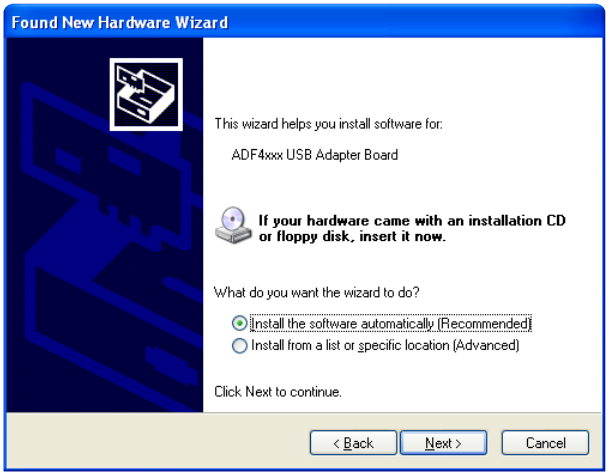
Found New Hardware Wizard
This wizard helps you install software for:
ADF4xxx USB Adapter Board
If your hardware came with an installation CD or floppy disk, insert it now.
What do you want the wizard to do?
Install the software automatically (Recommended)
Install from a list or specific location (Advanced)
Click Next to continue.
< Back
Next >
Cancel
10552-014

Figure 14. Windows XP USB Driver Installation, Install Options

2. Click **Next**.

Note that Figure 14 may list **Analog Devices RFG.L Eval Board** instead of **ADF4xxx USB Adapter Board**.

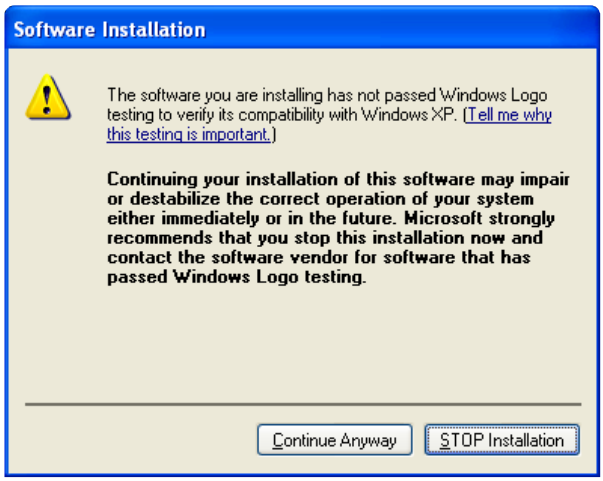
Software Installation
The software you are installing has not passed Windows Logo testing to verify its compatibility with Windows XP. (Tell me why this testing is important.)
Continuing your installation of this software may impair or destabilize the correct operation of your system either immediately or in the future. Microsoft strongly recommends that you stop this installation now and contact the software vendor for software that has passed Windows Logo testing.
Continue Anyway
STOP Installation
10552-015

Figure 15. Windows XP USB Driver Installation, Logo Testing

3. Click **Continue Anyway**.

Figure 16. Windows XP USB Driver Installation, Complete Installation

4. Click **Finish**.

EVALUATION BOARD SOFTWARE

The control software for the EVAL-ADF4150EB1Z is available on the CD included in the evaluation kit. To install the software, see the Software Installation section.

To run the software, first connect the board to the USB port of the PC and then click the **ADF4150** file on the desktop or in the **Start** menu (note that the revision number may be included in the file name). Confirm that **USB OK** is displayed at the top right corner of the software front panel display window (see Figure 17). Otherwise, the software has no connection to the evaluation board.

Note that, when connecting the board, it takes about 5 sec to 10 sec for the status label to change.

If the software is started before the board is connected to USB port, an error window opens, informing that the USB device was not found, and the **No USB** message is displayed in the top right corner of the software front panel window. In this case, connect the board to the USB port and click the **Connect USB** button.

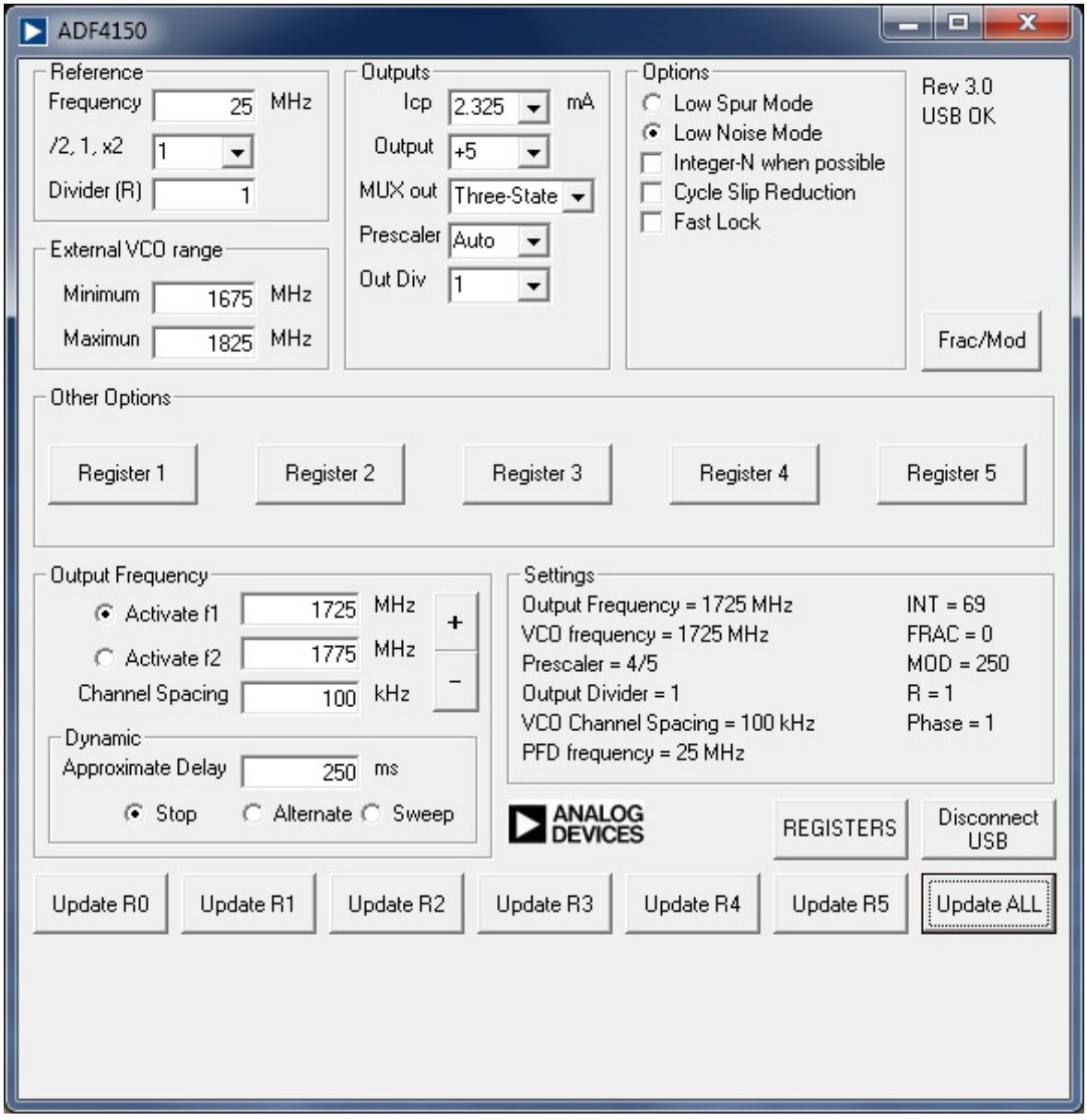

Figure 17. Software Front Panel Display

Use the **Frequency** text box in the **Reference** section to set the correct reference frequency. The default reference on the software window is at 25 MHz and matches the frequency of the TCXO present on the board.

Use the **Output Frequency** section to control the output frequency. To achieve single-tone on the RF output, type the desired output frequency in the **Activate f1** text box (in megahertz) and ensure that **Stop** is selected in the **Dynamic** section under **Output Frequency**. Selecting the **Alternate** option causes the frequency on the VCO output to switch between the **Activate f1** and **Activate f2** values. The delay time between frequency switches is controlled by the **Approximate Delay** option. The third option of the **Dynamic** section, **Sweep**, allows the output frequency to constantly change with the frequency step set by **Channel Spacing** starting from **Activate f1** until it reaches **Activate f2**. When the **Activate f2** frequency is reached, the sweep is repeated. Note that the **Sweep** option is not allowed if the **Activate f1** and **Activate f2** frequencies require different settings for the output divider (the **Out Div** box in the **Outputs** section). However, the **Alternate** option allows both frequencies to be achieved with different output divider values.

Some register settings may need to be set manually. Click the **Register 1** to **Register 5** buttons to open the register settings windows (see Figure 18).

Click the **REGISTERS** button to display the binary and hexadecimal values for all registers, as shown in Figure 20.

When a new register setting value is entered (see Figure 18), the relevant **Update Rx** (where x = 0 to 5) button becomes red, indicating that it must be clicked to program the part with the new value. Clicking the **Update ALL** button programs all register values simultaneously.

Click the **OK** button to confirm the new value in the **Register x Settings** (where x = 1, 2, 3, 4, or 5) window (see Figure 18). Click **Update Rx** to program the part with the new value. The new value is retained in the **Register x Settings** window if it is opened again.

If the value entered is outside of the range specified in the ADF4150 data sheet, an error message appears and the field is automatically updated to the lowest or highest value within the allowed range. Some limits are changed dynamically based on the values of other registers; for example, the highest allowed value for **Phase** in **Register 1 Settings** window depends on current value of the modulus (**MOD** in the **Settings** section), which is calculated based on the data from the **Reference** section and the **Channel Spacing** box in the **Output Frequency** section.

Click the **Cancel** button to abandon a register value change, and the new value is not retained in the **Register x Settings** window if it is opened again.

By clicking the **Frac/Mod** button, you can choose different modes of operation, including programming of specified integer, modulus, fractional, and output divider values. The output frequency and channel spacing are calculated automatically when the values shown in Figure 19 are entered in the **Frac_Mod_Form** window.

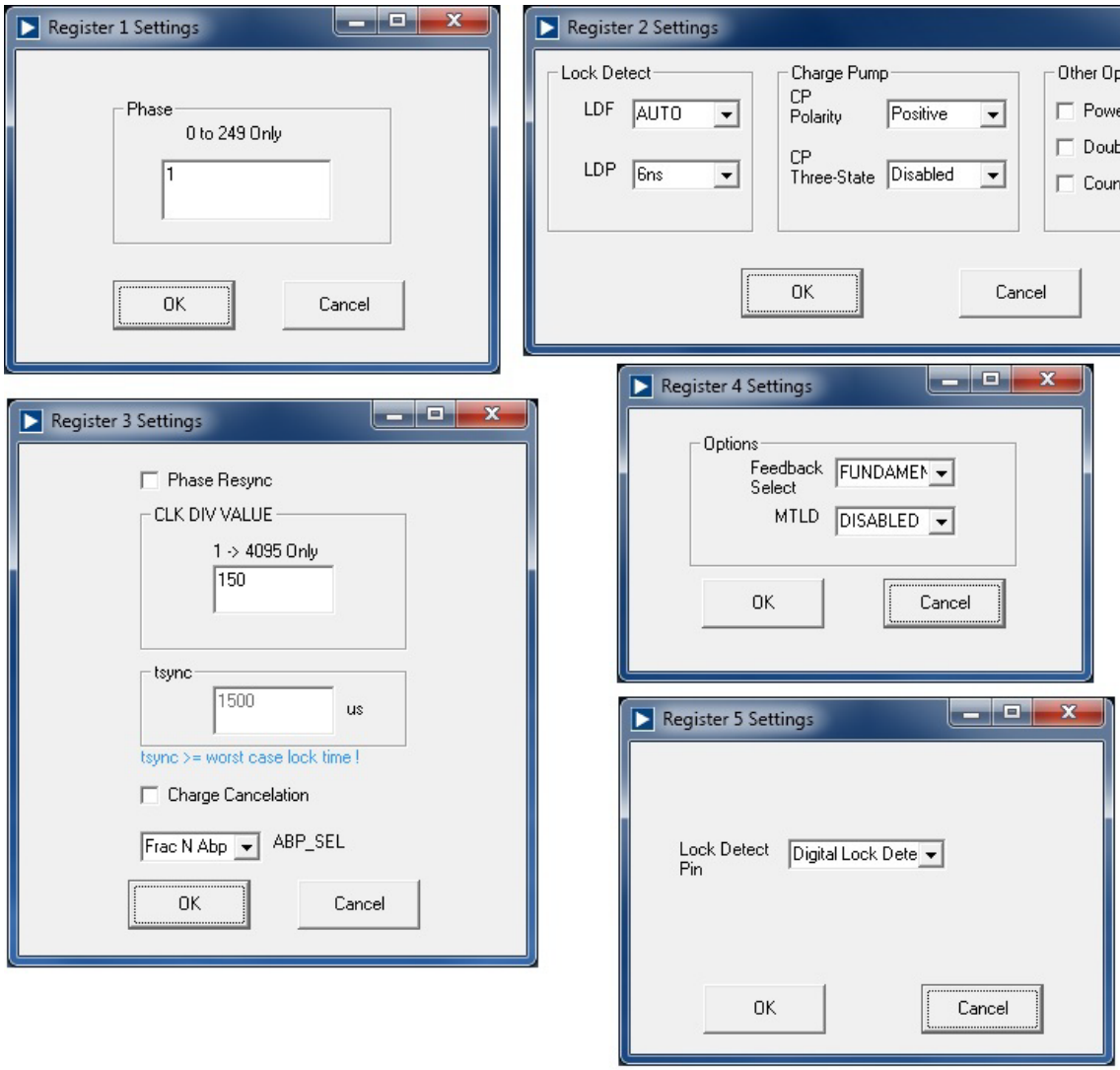

Figure 18. Register Settings Windows for Register 1, Register 2, Register 3, Register 4, and Register 5

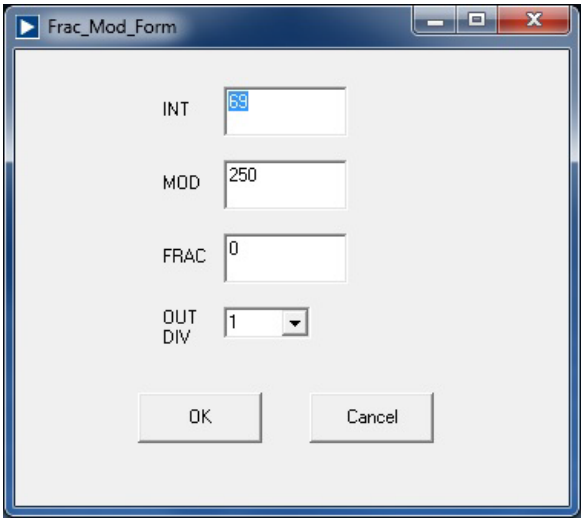

Figure 19. Frac_Mod_Form Window Allows Direct Control of Integer, Modulus, Fractional, and Output Divider Values

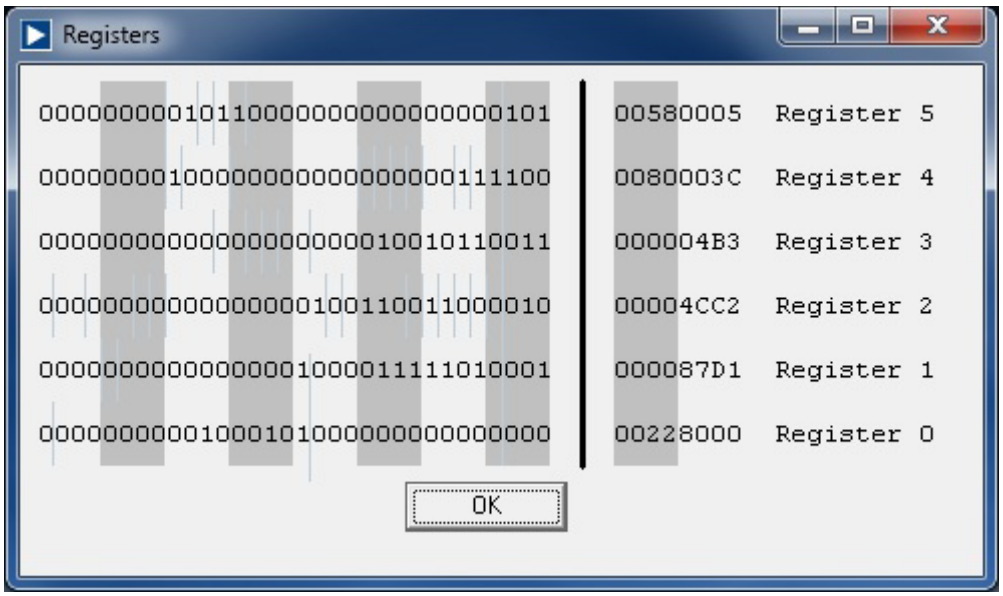

Figure 20. Registers Window Shows Current Values of All Registers of the Part

EVALUATION AND TEST

To evaluate and test the performance of the ADF4150, use the following procedure:

1. If using a different VCO and loop filter than provided on the board, ensure that a VCO and loop filter are properly inserted on the board. Use ADIsimPLL to generate the loop filter component values.
2. Install the ADF4150 software. Connect the evaluation board to a PC using the supplied USB cable. Follow the hardware driver installation procedure that appears.
3. If the on-board crystal oscillator is used, skip this step. If an external reference is necessary, connect a reference signal to the REFIN edge mount connector.
4. Connect the power supply to the board.
5. Connect a spectrum analyzer to Connector VCO_I/O.
6. Run the ADF4150 software.
7. In the software window, set the RF output center frequency (Figure 21 shows a screenshot of the spectrum analyzer taken at a frequency of 1750 MHz, which is in the midrange of the provided VCO). Set the PFD frequency as defined in ADIsimPLL, and program the reference frequency to 25 MHz if the on-board TCXO is used or to the frequency that has been supplied to the REFIN connector. See Figure 22 for the suggested setup.
8. Measure the output spectrum. Figure 21 shows a 1750 MHz output.

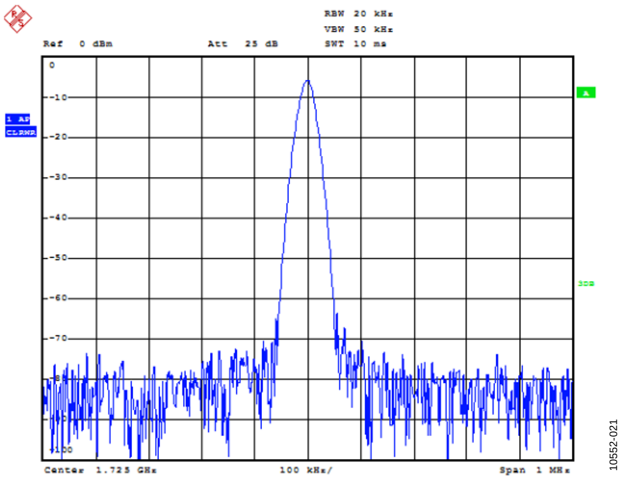

Figure 21. Spectrum Analyzer Display

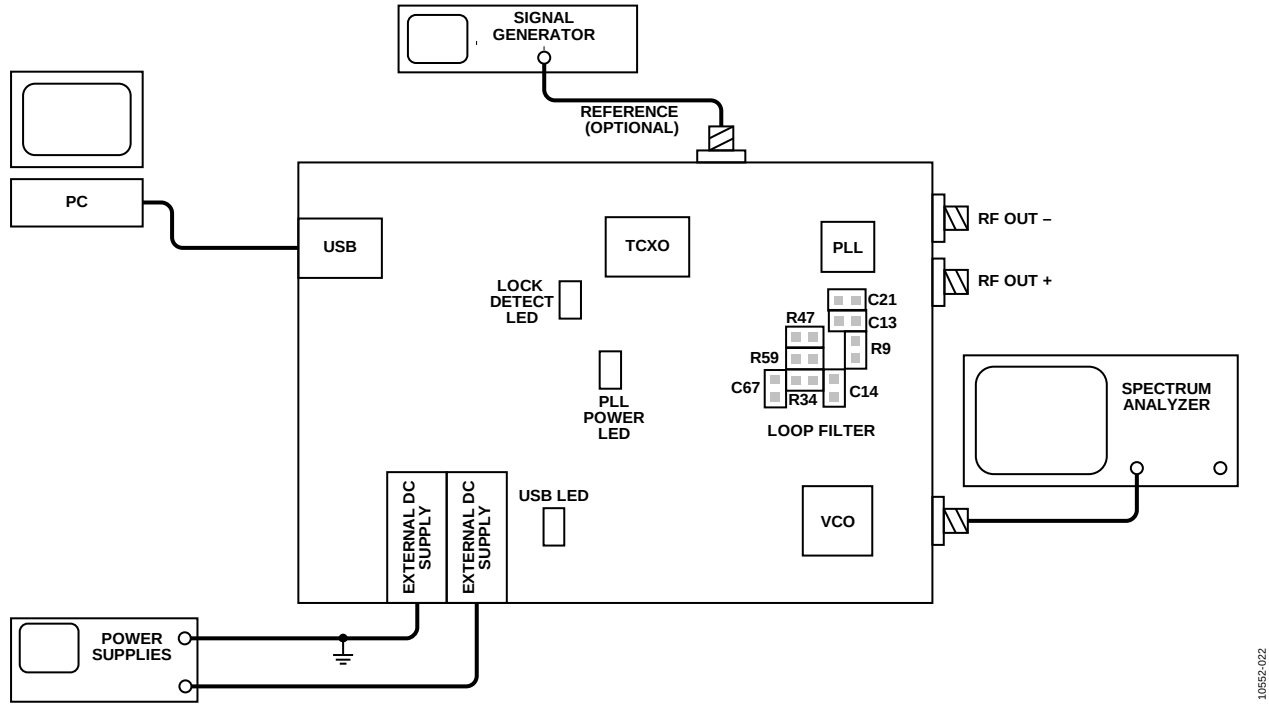

Figure 22. Typical Evaluation Setup

EVALUATION BOARD SCHEMATICS AND ARTWORK

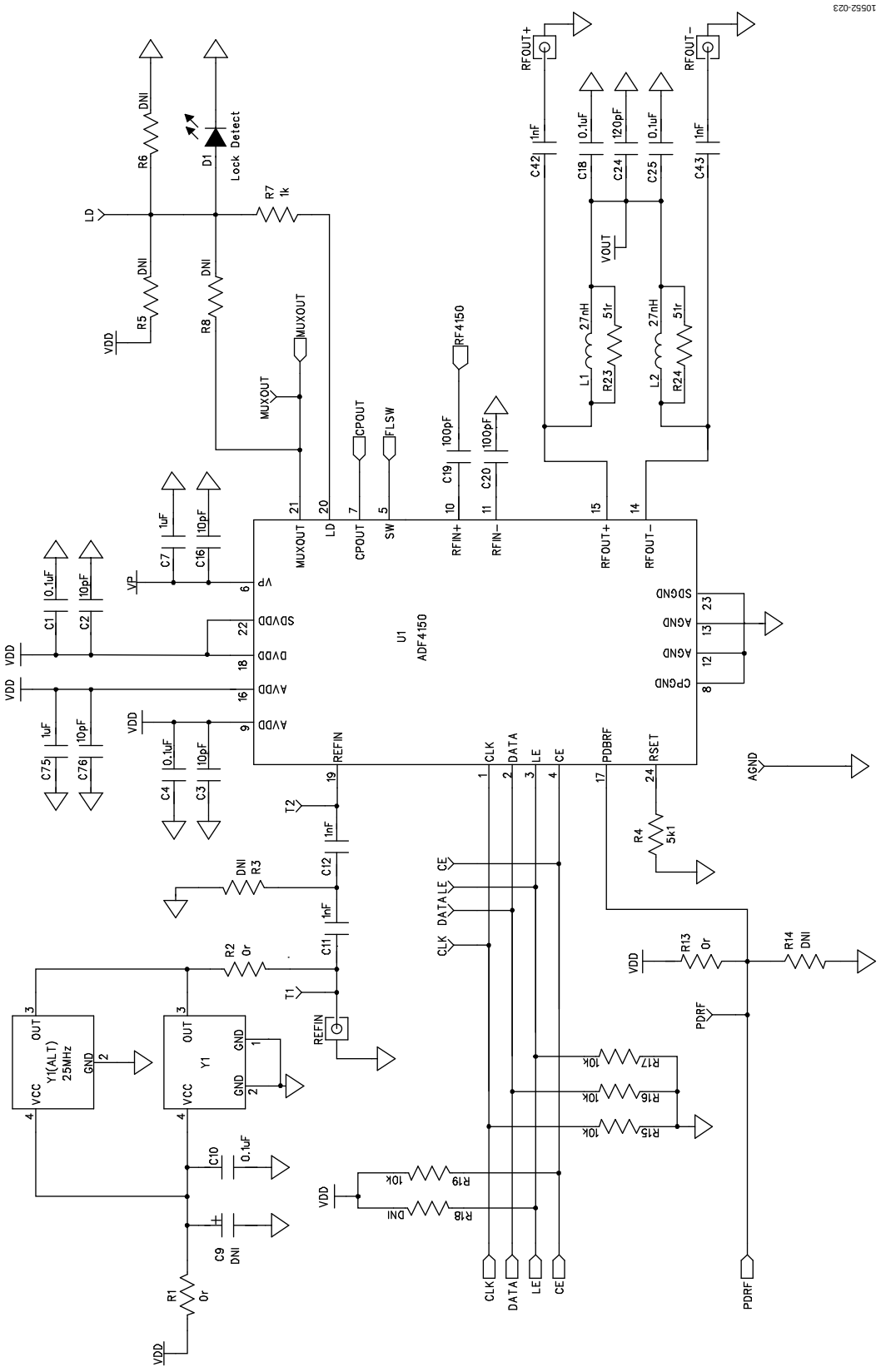

Figure 23. Evaluation Board Schematic (Page 1)

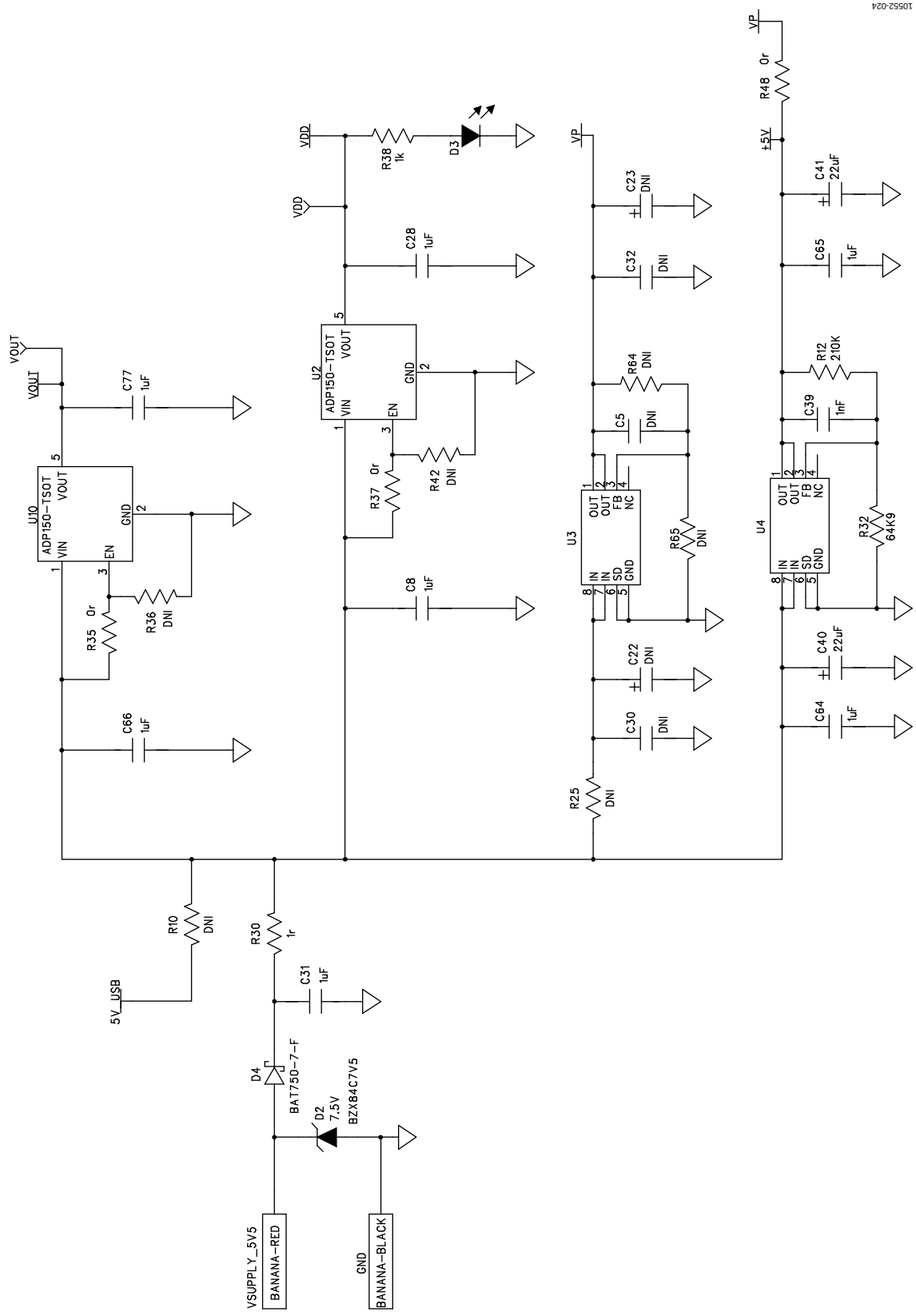

Figure 24. Evaluation Board Schematic (Page 2)

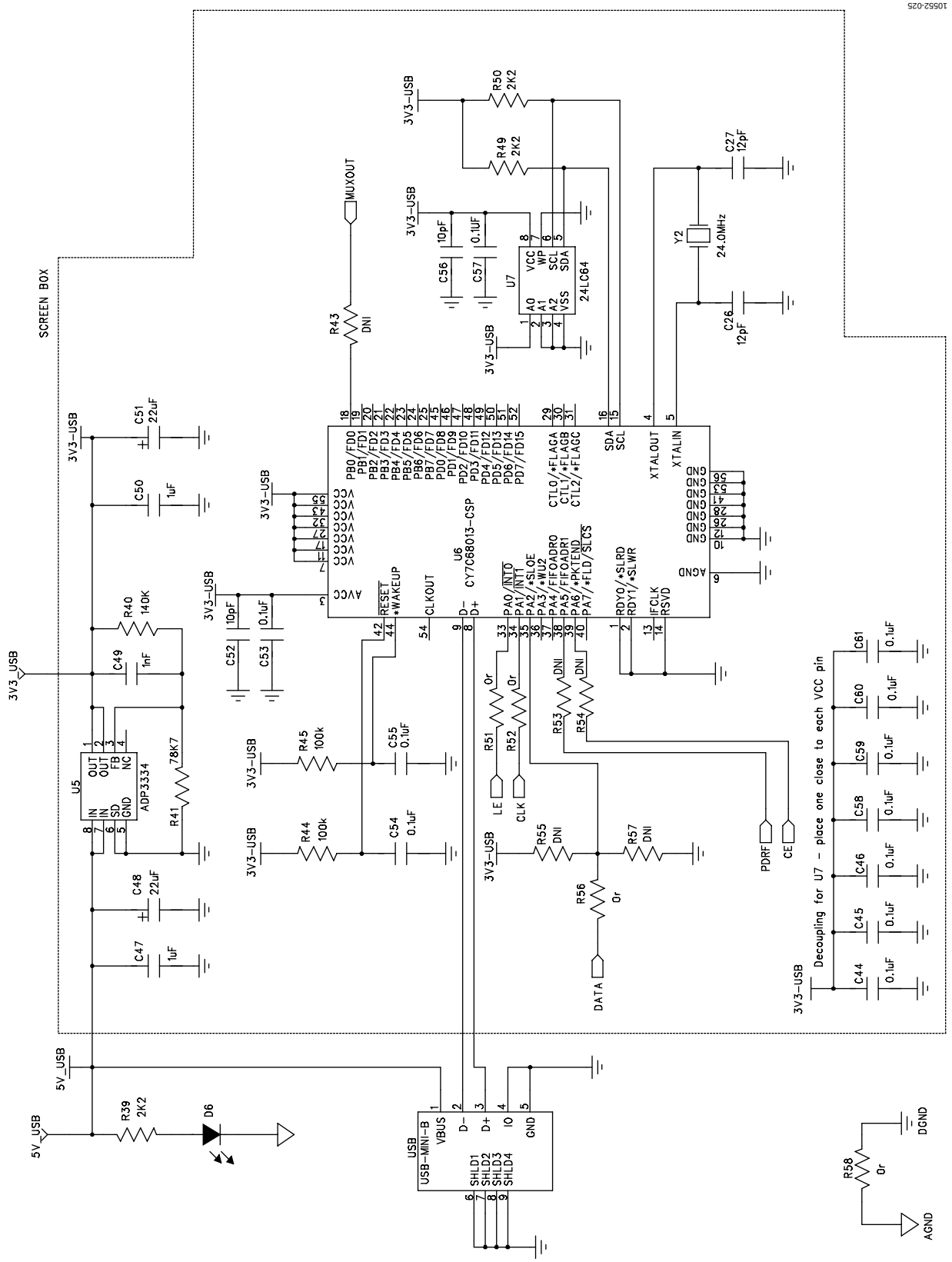

Figure 25. Evaluation Board Schematic (Page 3)

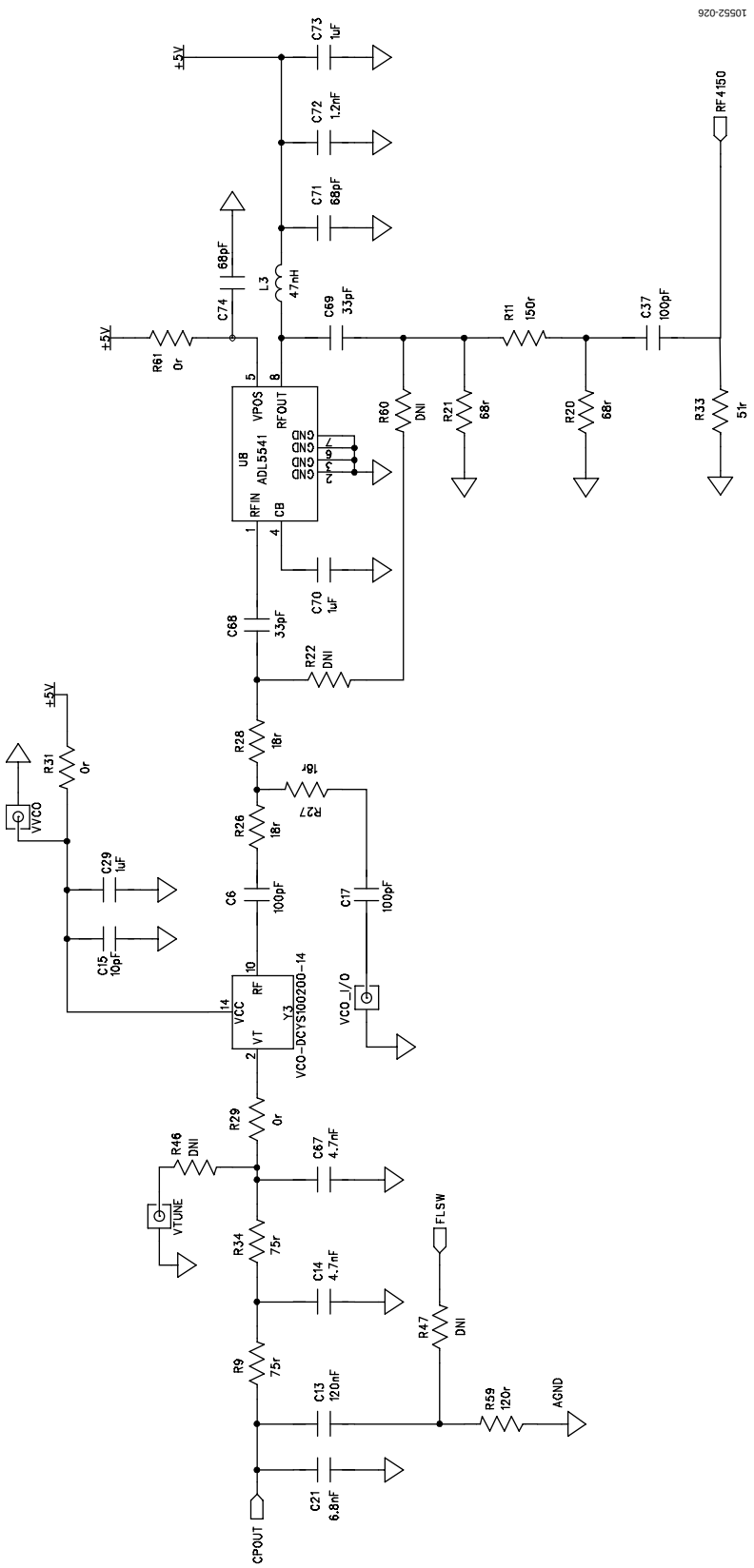

Figure 26. Evaluation Board Schematic (Page 4)

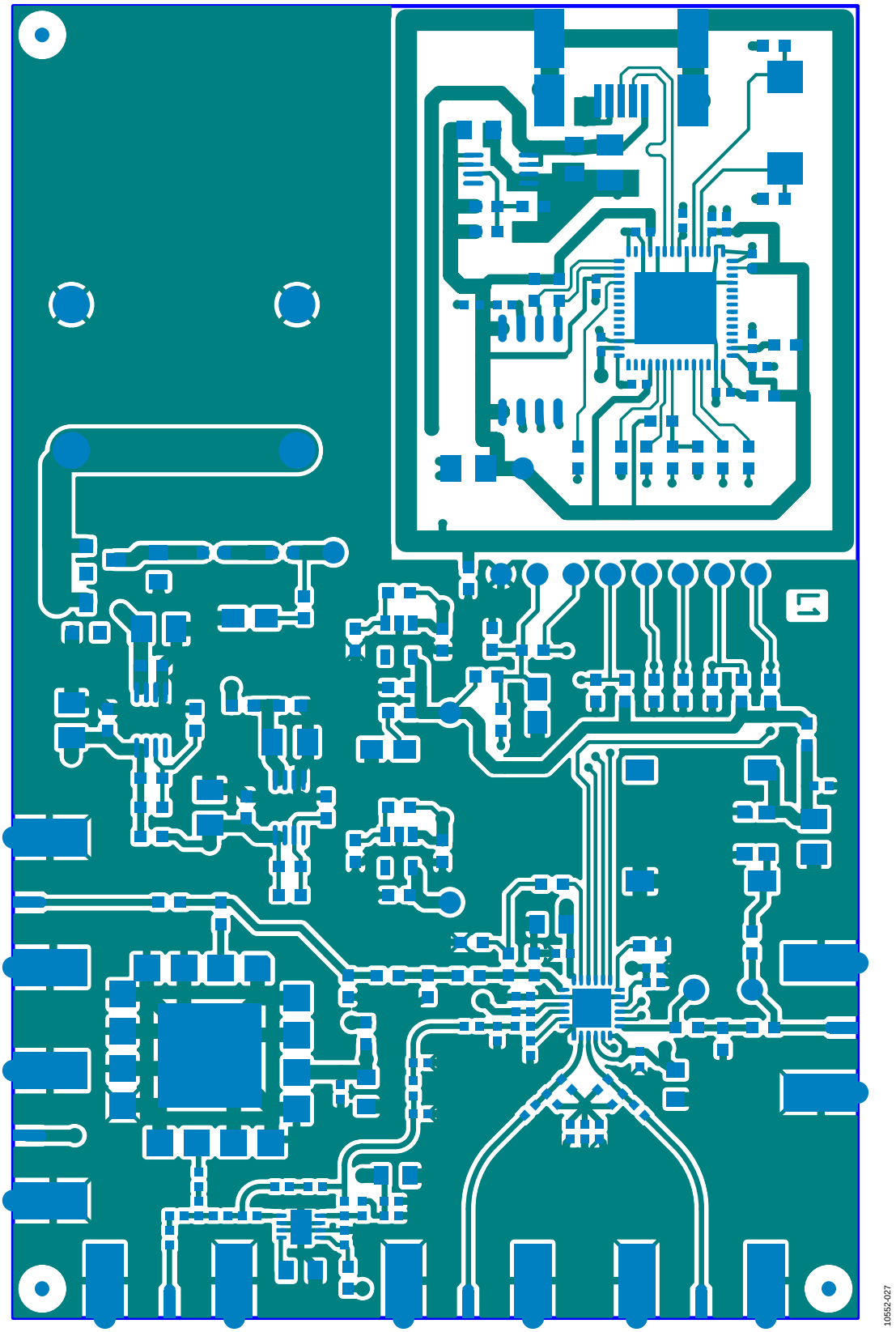

Figure 27. Layer 1 (Component Side)

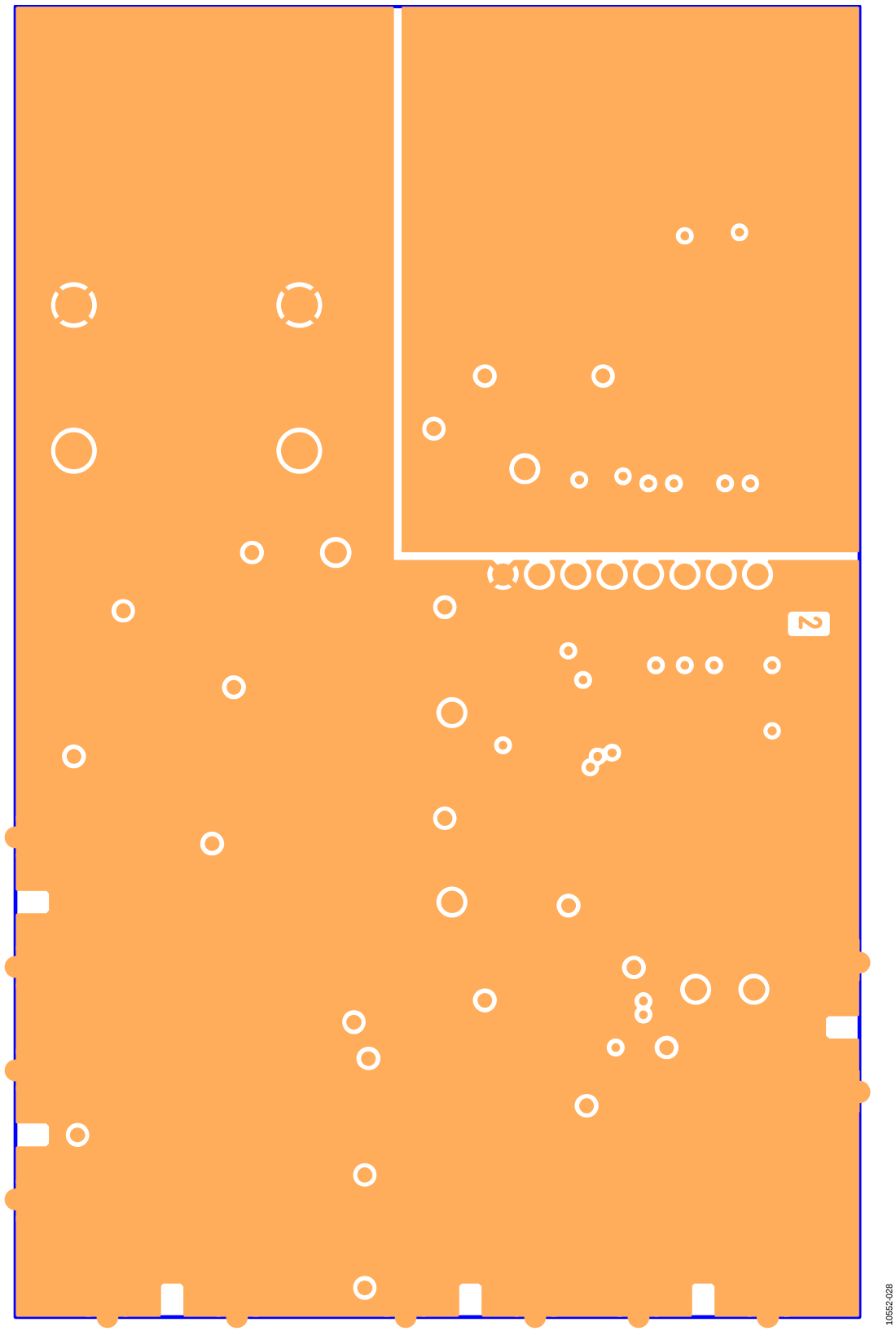

Figure 28. Layer 2 (Ground Plane)

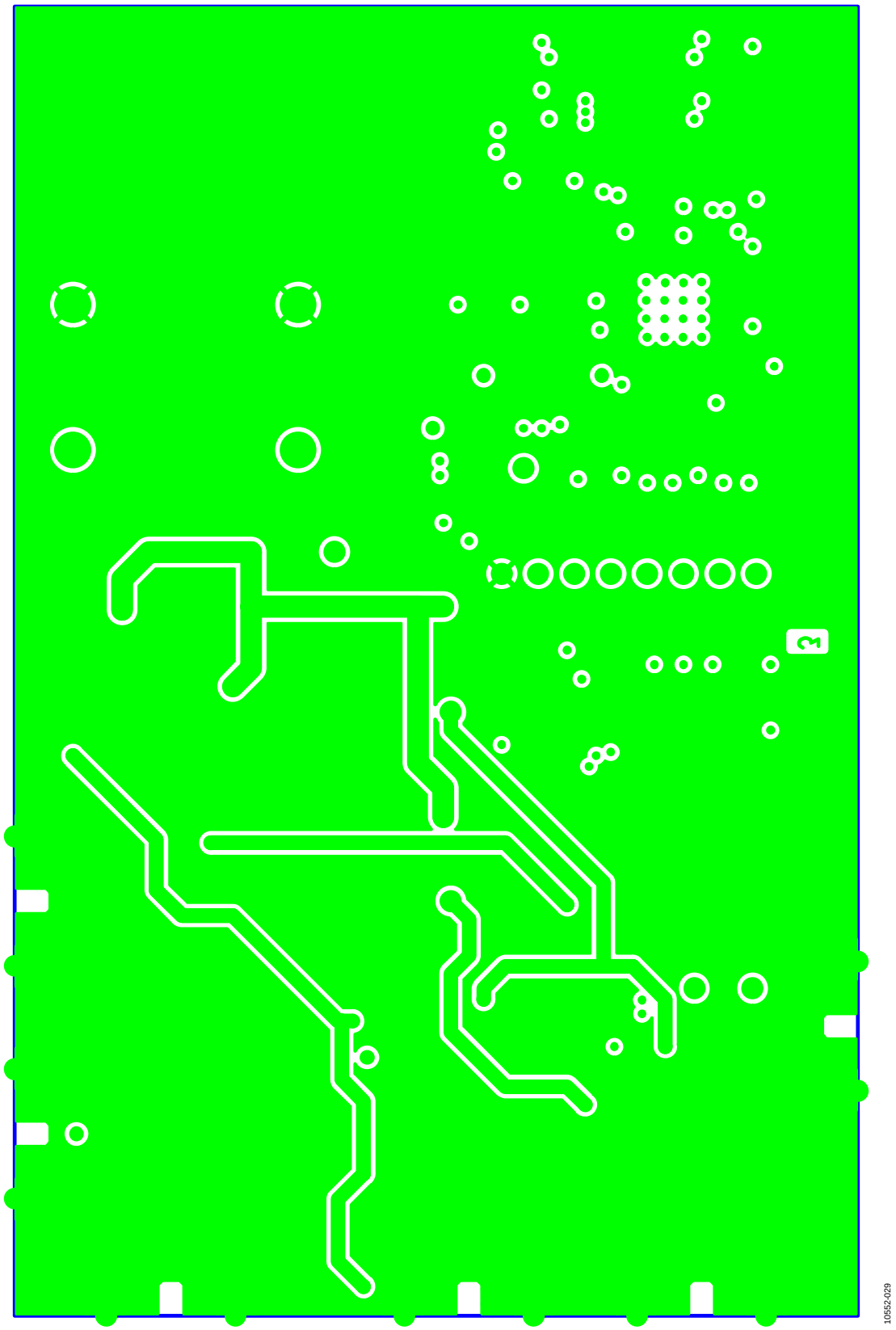

Figure 29. Layer 3 (Power Plane)

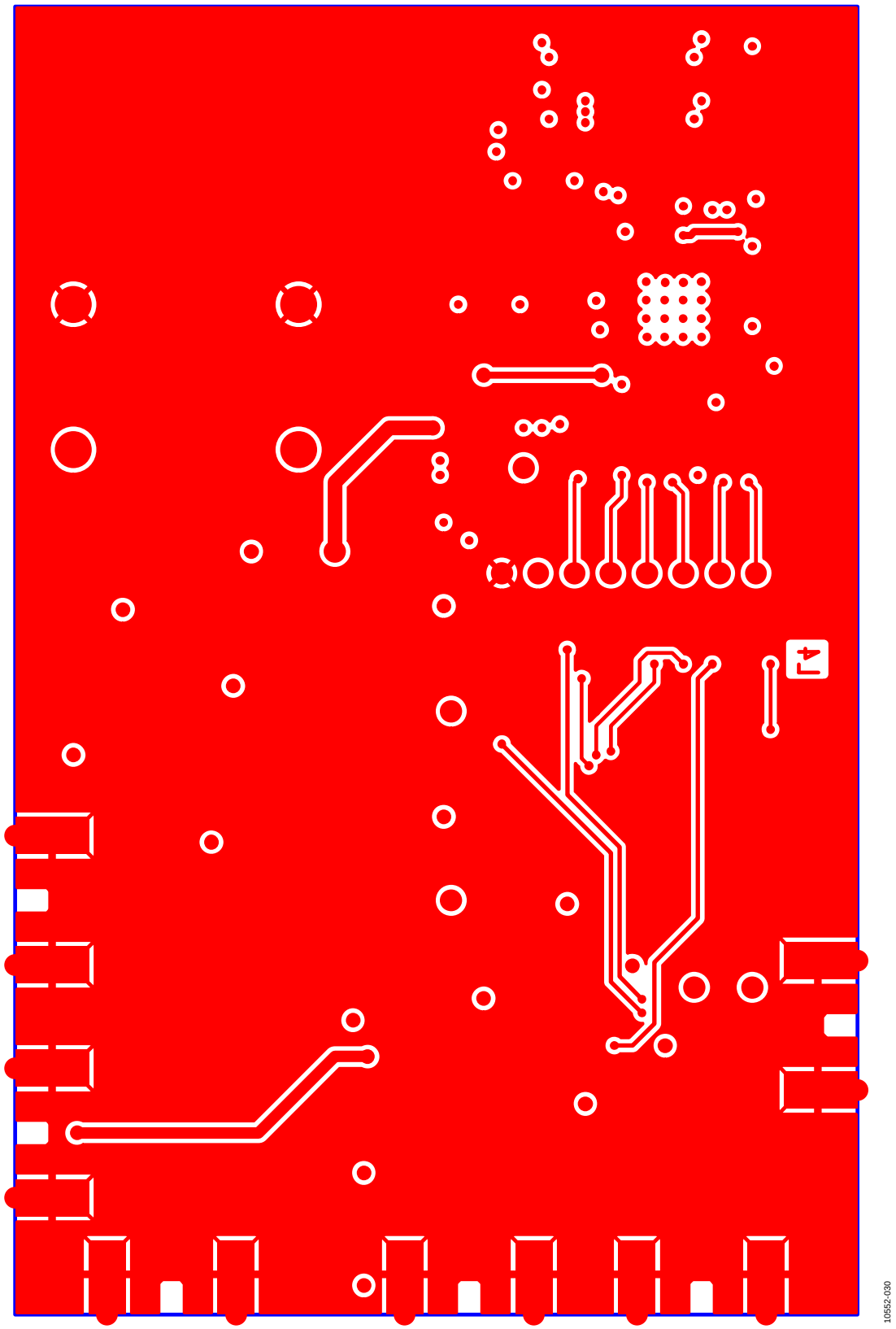

Figure 30. Layer 4 (Solder Side)

BILL OF MATERIALS

Table 1.

Reference Designator	Value	Description	Manufacturer/Part Number
AGND		Black test point	Vero 20-2137
C1, C4, C10, C18, C25, C44, C45, C46, C53, C54,C55, C57, C58, C59, C60, C61	0.1 µF	16 V, X7R ceramic capacitor	Kemet C0402C104K4RAC
C2, C3, C15, C16, C52, C56, C76	10 pF	50 V NP0 ceramic capacitor	AVX 04025U100GAT2A
C5	Do not insert	50 V NP0 ceramic capacitor	N/A
C6, C17, C19, C20, C37	100 pF	50 V C0G ceramic capacitor	Murata GRM1555C1H101JD01D
C7, C29, C31, C70, C73, C75	1 µF	Capacitor, ceramic, 1.0 µF, 50 V, X5R, 0805	Taiyo/Yuden GRM32RR71H105KA01L
C8, C28, C66, C77	1 µF	Capacitor, 0603, 1 µF, 10 V, X5R	Murata GRM188R61A105KA61D
C9	Do not insert	TAJ-A capacitor location, not inserted	N/A
C11, C12, C39, C49	1 nF	50 V NP0 ceramic capacitor	AVX 06035A102JAT2A
C13	120 nF	50 V X7R SMD ceramic capacitor	KEMET C0603C124K5RACTU
C14, C67	4.7 nF	50 V X7R SMD ceramic capacitor	Kemet C0603C472K5RAC
C30, C32	Do not insert	16 V X5R ceramic capacitor	N/A
C21	6.8 nF	50 V NPO SMD ceramic capacitor	Kemet C0603C682J5GACTU
C22, C23	Do not insert	6.3 V tantalum capacitor (TAJ-A case)	N/A
C24	120 pF	50 V NP0 ceramic capacitor	AVX 04025A121JAT2A
C26, C27	12 pF	50 V NPO SMD ceramic capacitor	Phycomp 2238 867 15129
C40, C41, C48, C51	22 µF	6.3 V tantalum capacitor (TAJ-A case)	AVX, TAJA226K006R
C42, C43	1 nF	Ceramic capacitor, 1000 pF, 50 V, C0G 0402	Murata GRM1555C1H102JA01D
C47, C50	1 µF	Ceramic capacitor, 1.0 µF, 25 V, X5R 0805	Taiyo/Yuden TMK107BJ105KA-T
C64, C65	1 µF	16 V X5R ceramic capacitor	Kemet C0603C105K4PAC-TU
C68, C69	33 pF	50 V C0G ceramic capacitor	Murata GRM1555C1H330JZ01D
C71, C74	68 pF	50 V C0G ceramic capacitor	Murata GRM1555C1H680JZ01D
C72	1.2 nF	50 V X7R ceramic capacitor	Murata GRM155R71H122KA01D
D1, D6		Green LED	Avago Technologies, HSMG-C170
D2	7.5 V	Zener diode, 7.5 V, 300 mW	Fairchild BZX84C7V5
D3		Red LED	Avago Technologies HSMS-C170
D4		Schottky diode, 0.75 A forward	Diodes Inc. BAT750-7-F
GND		Black 4 mm banana socket	Deltron 571-0100-01
L1, L2	27 nH	Coilcraft 0402CS SMD Inductor	Coilcraft 0402CS-27NX-LU
L3	47 nH	Coilcraft 0402CS SMD inductor	Coilcraft 0402CS-47NX-LU
R1, R2, R13, R29, R31, R35, R37, R48, R51, R52, R56, R58, R61	0 Ω	SMD resistor	Multicomp MC 0.063W 0603 0R
R3, R5, R6, R8, R10, R14, R18, R22, R25, R36, R42, R43, R46, R47, R53, R54, R55, R57, R60, R64, R65	Do not insert	0603 resistor location, not inserted	N/A
R4	5.1 kΩ	SMD resistor	Multicomp MC 0.063W 0603 5k1
R7, R38	1 kΩ	SMD resistor	Multicomp MC 0.063W 0603 1K
R9, R34	75 Ω	SMD resistor	CRCW060375R0FKEA
R11	150 Ω	0402 SMD resistor	Multicomp MC 0.0625W 0402 1% 150R
R12	210 kΩ	SMD resistor	Multicomp MC 0.063W 0603 210k
R15, R16, R17, R19	10 kΩ	SMD resistor	Multicomp MC 0.063W 0603 10K
R20, R21	68 Ω	0402 SMD resistor	Multicomp MC 0.0625W 0402 1% 68R
R23, R24, R33	51 Ω	0402 SMD resistor	Multicomp MC 0.063W 0402 51R
R26, R27, R28	18 Ω	0402 SMD resistor	Multicomp MC 0.0625W 0402 1% 18R
R30	1 Ω	SMD resistor	YAGEO (PHYCOMP) RC0603FR-071RL
R32	64.9 kΩ	SMD resistor	Multicomp MC 0.063W 0603 68k
R39, R49, R50	2.2 kΩ	SMD resistor	Multicomp MC 0.063W 0603 2k2

Reference Designator	Value	Description	Manufacturer/Part Number
R40	140 kΩ	SMD resistor	Multicomp MC 0.063W 0603 1% 140K
R41	78.7 kΩ	SMD resistor	Multicomp MC 0.063W 0603 1% 78K7
R44, R45	100 kΩ	SMD resistor	Multicomp MC 0.063W 0603 100K
R59	120 Ω	SMD resistor	Multicomp MC 0.063W 0603 1% 120R
REFIN, RFOUT+, RFOUT−		End-launch 50 Ω SMA jack	Emerson Network 142-0701-851
U1		PLL	Analog Devices ADF4150
U2, U10		3.3 V linear regulator	Analog Devices ADP150AUJZ-3.3
U3, U4, U5		Adjustable LDO regulator	Analog Devices ADP3334ARMZ
U6		USB microcontroller	Cypress Semiconductor CY7C68013A-56LFXC
U7		64 k I^2C serial EEPROM	Microchip Technology 24LC64-ISN
U8		50 MHz to 6 GHz RF/IF gain block	Analog Devices ADL5541ACPZ
USB		USB Mini-B connector (USB-OTG)	Molex 54819-0578
VCO_I/O, VTUNE, VVCO		End-launch 50 Ω SMA jack	Emerson Network 142-0701-851
VSUPPLY_5V5		Red 4 mm banana socket	Deltron 571-0500-01
Y1 (ALT)	25 MHz	SMD temperature compensated crystal oscillator	Rakon TXO225B
Y2	24 MHz	SMD crystal	ECS International ECS-240-12-20A-TR
Y3	1700 MHz to 1800 MHz	VCO	Mini-Circuits ROS-1800+

RELATED LINKS

Resource	Description
ADF4150	Product Page, Fractional-N/Integer-N PLL Synthesizer
ADP150	Product Page, Ultralow Noise, 150 mA CMOS Linear Regulator
ADP3334	Product Page, High Accuracy Low IQ, 500 mA anyCAP® Adjustable Low Dropout Regulator
ADL5541	Product Page, 50 MHz to 6 GHz RF/IF Gain Block, Gain of 15 dB

NOTES

I^2C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).

ESD Caution

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

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